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The effect of road lane width on cyclist safety in urban areas

Schramm, A., Rakotonirainy, A.
Centre for Accident Research and Road Safety
email: a.schramm@qut.edu.au

Abstract

Research has shown that road lane width impacts on driver behaviour. This literature review provides guidelines to assist in the design, construction and retrofitting of urban roads to accommodate road users' safety requirements. It focuses on the impacts of lane widths on cyclists and motor vehicle safety behaviour. The literature review commenced with a search of library databases. Peer reviewed articles and road authority (local, state and national) reports were reviewed. The majority of studies investigating the effects of lane width on driver behaviour were simulator based, while research into cycling safety involved data collected from actual traffic environments. Results show that marked road lane width influences perceived task difficulty, risk perception and possibly speed choice. The positioning of cyclists in traffic lanes is influenced by the presence of on-road cycling facilities and the total roadway width. The lateral displacement between bicycle and vehicle is smallest when a bicycle facility is present. Lower, or reduced, vehicle speeds play a significant role in improving bicyclist and pedestrian safety. It is also shown that if road lane widths in urban areas were reduced, to a functional width that was less than the current guidelines of 3.5m, it could result in a safer road environment for all road users.

Key Words

Cyclist, Urban, Geometric Design

Introduction

The purpose of this review is to determine the relationship between lane widths and the safety of cyclists on urban roads. There has been limited research regarding roadway design and cyclist safety. The research that has been conducted has not been comprehensively collated and summarised and lacks a substantive discussion of factors and principles that could be used by road engineers to improve cyclists' safety. As road treatments affect all road users it is important to investigate the effects of changes to road design on each road user group independently. Following the identification of the effects of road design factors on separate road user groups it is important to understand how the design factors influence the interactions between user types.

This paper is organised as follows. The first section will outline the methodology and scope of the literature review. Road user requirements will then be examined, followed by current road engineering guidelines. The review will then explore the effect of lane width on driver (motor vehicle) behaviour, and subsequently the effect of lane widths on cyclist behaviour and safety. The final section of the review will summarise the available literature.

Methodology

The initial process of the literature review was a thorough search across available online databases. Multiple searches were undertaken using a variety of search strategies. Searches were conducted using electronic databases (Web of Science, Science Direct, and Australian Transport Index), as well as internet searches using Google Scholar. Individual journals were also searched (Transportation Research Record, Accident Analysis & Prevention, Ergonomics, Journal of Transportation Engineering, ITE Journal) and agencies with an interest in geometric design of roads were contacted. All papers identified (approximately 94 research papers, excluding engineering guidelines, that were available to the authors) through the search procedures were scanned for relevancy. Relevant papers were defined as those that evaluated the safety of road geometric designs for urban environments, excluding high-speed roads (freeways and motorways, where cyclists are usually prohibited from riding). From the identified papers, 71 were excluded. The most common reasons that resulted in exclusion were: research was conducted using data exclusively from rural locations, the research investigated the effect of lane width on crashes at roadwork locations, research focused was on a specific crash type, or the research examined geometric design features other than lane width (such as median strips or landscaping). Due to the limited research in the area of cycling safety, no geographical restrictions (country of origin) were implemented. However, there was a preference for auto-centric locations such as USA, UK, New Zealand and Australia. Also as a result of the limited available research, research which used a range of research methodologies were

included, which can make comparisons between findings difficult. Only peer review articles and road authority reports by local, state and national bodies were reviewed.

The papers included a variety of research approaches. Research into cycling safety included observational and modelling research approaches. The majority of studies investigating the effects of lane width on driver behaviour were simulator based.

This review has not examined several road features that were considered to be outside the focus of lane widths and urban roads. These factors were believed to be issues important enough to be investigated independently. These issues include:

- A detailed review of lane narrowing as a traffic calming measure
- Road shoulders, as these were considered as separate issue in geometric design
- Lane width requirements at intersections
- Other intersection measures, such as advanced stop lines for bicycles
- Several aspects regarding traffic conflict points, such as lane merging and lane splitting, are not addressed

This review is limited to urban road segments without features (intersections, and other features). This review builds on earlier work conducted for the Queensland Department of Main Roads (now the Department of Transport and Main Roads). Early research into the safety aspects of geometric design parameters has focussed on rural roads. The Centre for Accident Research and Road Safety- Queensland (CARRS-Q) was commissioned to review literature relating to the impact of reduced lane widths on urban roads. This paper further investigates the impact of reduced lane width on the safety implications of narrow lane widths for cyclists, and the road users with whom cyclists have the greatest level of conflict. While the research into bicycle crashes in South East Queensland does show the majority of bicycle crashes occur at intersections (54.01%), a large number of crashes involving cyclists occur on road segments that do not contain intersections (45.99%) [1]. Future research could consider the effect of lane width on bicycle safety at intersections, and other conflict points.

Road user requirements and engineering guidelines

Every vehicle occupies a defined space on the roadway, whether stationary or moving. When discussing geometric design features, specifically lane width and road user safety, it is important to consider the capability of all vehicle types using the road. For the purpose of this review, we will focus on the requirements vehicles that place the most pressure on cyclists' safety through size (heavy vehicles) or likelihood of crash involvement (passenger vehicles).

a) Heavy vehicles

One aspect that requires careful consideration is the tracking ability of heavy vehicles, particularly multi-combination vehicles. Tracking ability refers to the ability of the attached unit to follow the same path as the lead unit. This is quantified by the total swept width, which includes the lateral displacement the trailer undergoes when travelling at speed, in addition to the vehicle width and is dependent on the configuration of the vehicle, the environment and road factors [2]. Prem and others [3] examined the width requirements of various heavy vehicle configurations, ranging from a truck and trailer combination to a rigid +3 (a rigid truck plus dog trailer), when travelling on rural roads using a straight travel path in Australia. Comprehensive testing, incorporating a range of road surface environments (various combinations of roughness and cross-slope measure), was conducted. Lateral displacement was shown to increase as speed increased for all vehicle combinations [3]. Models of estimated lane width requirements for heavy vehicles were developed, based on the mean measured lateral displacement and the maximum Australian legal vehicle width (2.5m). The results indicated that a majority of heavy vehicle configurations had a lane width requirement of less than 3.2m when travelling at 90kph, and 3.1m when travelling at 60kph. Prime-movers and semi-trailers were shown to have the smallest lane width requirements, estimated at 2.8m when travelling at 60kph. Rigid +3 vehicles were shown to have the greatest lane width requirement, needing 3.4m to avoid lane deviation when travelling at 60kph, increasing 3.85m when speed increased to 90kph. This research demonstrated that greater lane widths were required when travel speed increased, although there was no measure of statistical importance of this finding.

b) Passenger vehicles

Road design standards are usually determined by the characteristics of passenger vehicles, with passenger vehicle operating speeds often the critical input used to determine the safety of the road [4]. It is assumed from the design and operating ability of private passenger vehicles, they would be able to safely navigate on lanes that provide for the requirements of heavy vehicles.

c) Pedal cycles

There is no single definition of the operating space of a bicycle. The minimal operating space was established based on data that has found most bicycle types have a functional width of 0.65m [5]. Research suggests that the actual bicycle operating space requirements is 0.75m [5]. This allows for slight movements in travel path as a result of operator control. However it is widely regarded that the operating space required by a bicycle is greater than this. The operating space for a typical bicycle ranges from 0.75m to 1.4m, and is dependent on the skill level of the bicycle operator. On-road bicycle lanes are a popular road treatment to provide dedicated space for bicycle travel. Perhaps as a reflection of the diversity of the cycling population (skill level and age), or as result of the range of attitudes towards cyclists by the road using public and/or governments, there is little consensus regarding the recommended widths for on-road bicycle lanes (see Table 1).

Table 1. Selected recommended bicycle lane width: various countries.

| | Netherlands ¹ | Germany ¹ | Sweden ¹ | Norway ¹ | USA ² | UK ³ | NZ ⁴ | Australia ⁵ |
|------------------------------------|--------------------------|----------------------|---------------------|---------------------|------------------|-----------------|-----------------|------------------------|
| Recommended Bicycle lane width (m) | 1.0 | 1.0 | 1.2 | 1.6 | 1.2 1.5* | 1.5 2.0^ | 1.5† 1.9‡ | 1.5 |

¹ Allen et al [5]² American Association of State Highway Transportation Officials (AASHTO) Guide [6]³ Department of Transport [7]⁴ Transit New Zealand [8]⁵ Austroads [9]

* 1.5m minimum is recommended with an increase in bus and/or truck volume

^ 2.0m minimum is recommended on roads with higher speeds (≥ 65 kph)† 1.5m desirable minimum when vehicle speed is ≤ 50 kph‡ 1.9m desirable minimum when vehicle speed is ≥ 70 kph**Current road engineering guidelines**

Australian road engineering guidelines are developed by Austroads. Currently, the guidelines indicate that the preferred lane width for urban roads is 3.5m [10]. This is towards the upper end of lane widths recommendations for arterial roads when compared with international guidelines (see Table 2).

Table 2. Selected lane widths, according to roadway classification: various countries. (Extract from Hall et al [11])

| Country | Roadway classification | | |
|----------------|------------------------|---------------------|----------------|
| | Freeway | Arterial | Minor or Local |
| Brazil | 3.75m | 3.75m | 3.0m |
| Canada | | 3.0 to 3.7m (rural) | 3.0 to 3.3m |
| China | 3.5 to 3.75m | 3.75m | 3.5m |
| Denmark | 3.5m | 3.0m | 3.0 to 3.25m |
| France | 3.5m | 3.5m | 3.5m |
| Germany | 3.5 to 3.75m | 3.25m to 3.5m | 2.75 to 3.25m |
| Japan | 3.5 to 3.75m | 3.25m to 3.5m | 3.0 to 3.25m |
| Poland | 3.5 to 3.75m | 3.0m to 3.5m | 2.5 to 3.0m |
| United Kingdom | 3.65m | 3.65m | 3.0 to 3.65m |
| USA | 3.6m | 3.3 to 3.6m | 2.7 to 3.6m |

The road design guidelines developed for Australia do include concessions for narrower lane widths, with the minimum stated as 3.0m. The situations where narrower lanes may be appropriate include: minimal heavy vehicle flow, low speed environments, a limited road reserve available, financial constraints, or if the safety records for the road are satisfactory. These guidelines also include recommendations for when lanes wider than recommended should be implemented. It is suggested that wider lanes be used when there is a high percentage of heavy vehicle traffic, if the left lane is to be used by cyclists, or the horizontal curve geometry requires an increase in lane width.

There is a specific section in the Australian Traffic Engineering Guidelines that address issues specific to catering for bicycles. This section provides a guide for the implementation of bicycle facilities [9]. Traffic

volume is the sole determinant of whether a bicycle facility is to be provided, or if lane sharing is to occur. Lane sharing is recommended when the daily traffic volume is less than 3000 motor vehicles. Facilities that cater for cyclists' requirements should be implemented when the daily traffic volume is greater than 3000 motor vehicles. These facilities are defined as wide kerbside lanes, shared bicycle/car parking lanes or exclusive bicycles. The type of facility employed is based on the signed speed limit of the road. Wide kerbside lanes are only considered appropriate in 60kph or 70kph speed zones. These wide kerbside lanes should be between 4.0m and 4.2m wide. This provides adequate clearance between bicycles and vehicles, but does not allow sufficient space for vehicles to travel two abreast within the lane. Marked exclusive bicycle lanes are considered appropriate where bicycle traffic is concentrated, or demand is demonstrated. These exclusive lanes are also the preferred option when the signed vehicle speed is 80kph or greater, although the recommended width of these lanes is speed dependent (see Table 3). Research has suggested that a marked bicycle facility should be provided when the available travel space is less than 4.57m [12].

Table 3. Bicycle and traffic lane widths, related to marked vehicle speeds. [9]

| Marked speed limit | Bicycle lane width | Traffic lane width |
|--------------------|-------------------------|--------------------|
| <60kph | 1.0m (absolute minimum) | 3.0m |
| 60kph | 1.5m | 3.0 to 3.5m |
| 80kph | 2.0m | 3.5m |
| 100kph | 3.0m | 3.5m |

Effect of lane widths on motor vehicle driver behaviour

This section examines research investigating the way in which lane width modifies driver behaviour. Particular focus will be directed at the difficulty of the driving task, driver speed choices, and the perceived crash risk on "narrow" travel lanes in the urban road environment.

Recent research by Godley and others [13] has investigated the relationship between lane width and rated difficulty of the driving task. Using a driving simulator various lane width configurations were examined. An established instrument, NASA Task Load Index, was used to measure the mental, physical and temporal demand, as well as performance, effort and frustration level for different roadway environments. However, the instrument utilised has not been validated as an instrument measuring the difficulty of the driving task. Results from this research demonstrate that narrow lane widths were rated more difficult to drive, with subjective difficulty ratings shown to be reduced when lane widths were increased. There is limited research in this area, and further research is required to determine the relationship between the subjective rating of task difficulty and road user safety.

The influence of lane width on self-selected operating speed has been investigated through several methods. A number of studies have investigated the effect of lane width on driving speed through road curves in suburban, low speed environments. Research, involving a low speed environment, has been conducted on experimental conditions on real roads. However, results have not been congruent. Poe & Mason [14] found that reduced lane widths resulted in a decrease in observed speed, with the greatest reduction at the curves mid-point. In contrast, other research found that lane width did not significantly influence operating speed through horizontal curves [15]. As this research was conducted on low-speed urban and suburban streets additional research would be required to generalise the findings and determine the effect of lane widths on roads with higher speeds.

Further research has been conducted regarding the effect of lane widths on straight line travel. Research collecting data from low-speed suburban roads suggests that lane width has a significant impact on speed choice on straight road sections [15]. This research demonstrated that an increase in lane width by 1m, speeds are predicted to increase by 15kph. Additional research using a driving simulator also supports these results. In the test condition where the operating lane width was 2.5m, 1m narrower than the guidelines established by Austroads [10], mean speed was found to be significantly reduced [13]. In terms of the measured change in speed choice, this was shown as 2.23kph reduction in mean speed when compared with the mean speeds when the lane width was 3.0m. However, the influence of lane width on speed selection was shown to be non-linear. The results from the simulator indicated that there was no significant difference in mean speed for lane widths for 3.0m and 3.6m [13].

In addition to the effect of lane width, investigation has also shown that the total number of lanes also influences driver speed. Research has found that speed increases as the number of lanes increases [16]. This research

demonstrates that total roadway width can be important in determining driver speed choices, independent of individual traffic lane width.

A reduction in speed choice has several flow-on effects which may also increase road user safety. Research has also demonstrated that speed variability decreases when mean driving speed is reduced [17]. It has shown that greater variability in travel speeds is associated with an increased risk of crash. Therefore, it is hypothesized that a reduction in lane width that induces a reduction in speed would lower the crash risk of vehicles. Lower travel speed also has an effect on vehicle control. Research outside the area of lane widths has shown that increased travelling speeds increases the variability in vehicle positioning within lanes [18].

An investigation into perceptual lane widths required drivers to subjectively rate the perceived crash risk for various road configurations presented in a driving simulator. Drivers rated the risk they felt on a scale ranging from safe to dangerous. These results will be reviewed with cautions, as while the scale was designed specifically for the study, it had not been independently validated. A trend was identified that suggested that narrow roads of 2.5m were perceived as having a higher level of risk, although no significant differences in risk ratings between the lane widths was found [13]. Further research is required to validate the trend and make definitive conclusions.

The review of the research has found that the general consensus is that narrow lane widths result in a reduction in chosen travel speed. Lower travel speeds are associated with an increase in perceived safety [16]. There is also a reduction in speed variability, and vehicle positioning variability. All these indicate that narrower lane widths would have a positive effect on road safety for vehicle occupants. Narrow travel lanes did not increase the drivers' perceived risk of the road environment. However, narrower lanes did increase the perceived difficulty of the driving task. The increase in task difficulty could have possible, as yet undetermined, implications for road safety. An important note is that the research reviewed did not explicitly correlate speed with safety.

Effect of lane widths on cyclist behaviour and safety

The focus of this section is to explore the implication of geometric design factors of roads on bicycle safety. There has been much research conducted regarding the safety of vehicle lane widths for various roadway situations. This has focused primarily on the safety for heavy vehicles and passenger cars as shown in the previous section. As far as we are aware, no such body of research exists in this area for the safety width of lane widths for bicycles. While traffic engineering recommendations exist regarding where bicycle lanes should be implemented, and the required width of bicycle lanes, little research exists on which to base these recommendations.

Research has determined that there are several factors that influence a cyclist's route selection. These relate to purpose of trip (recreational, commuting or fitness) and cycling ability. The majority of research is based in the United States. Substantial research exists regarding commuter cyclists' route choice. The following preferences, addressing facility and route factors, have been identified: shorter travel times; continuous bicycle facilities; smooth riding surface; flat to moderately hilly terrain; an on-road bicycle facility, rather than a separate path; lower traffic volume and the absence of parked cars [19]. Additional research suggests that segregated off-road bicycle facilities should be considered as recreational facilities, rather than commuter facilities [20]. Little research has investigated the preferences for cyclists whose purpose of travel is actual training.

In the absence of extensive literature on the relationship between crashes and road design for bicycles, we re-examined the concept of safety into three different groups:

- Actual safety, a typical measure being crash data;
- Perceived safety, a subjective measure expressed by the road users;
- Or inferred safety, an indirect assessment of safeness.

If a direct measure of safety is not available, it may be appropriate to evaluate the inferred safeness of road geometric designs. Two indirect measures that may be indicators of bicyclists' safety include the position of a motor vehicle in relation to the bicycle, and the motor vehicles speed when passing the cyclist [21].

There has been an increase in the popularity of bicycling as a physical activity, with cycling moving from sixth in 2002 to fourth in 2007 on the list Australian citizens' most popular activity [22; 23]. Cycling as a mode of transport has also increased, with bicycle mode share more than doubling to between 2006 and 2008 to 9% in Melbourne [24]. As a result road authorities have considered design measures to improve cyclist safety. One design measure that has gained popularity is the implementation of on-road bicycle lanes. The primary aim of

bicycle lanes is to improve cyclist safety, namely through improving the interactions between bicycles and vehicles. Foundation research into the interaction between bicycles and vehicles has demonstrated that bicycle lanes influence both driver and bicycle behaviour.

Several roadway factors have been shown to influence a cyclists' travel path. Cyclists are less likely to demonstrate unpredictable behaviours when a cycle lane is present. This predictable behaviour is most evident through a more consistent travel path on the roadway when riding in a marked on-road bicycle lane [25]. The presence of a cycle lane is also a predictor of the cyclists positioning from the road curb. Several studies have demonstrated that a presence of a cycle lane increases the distance between the cyclist and the road edge [26; 25]. The level of facility, whether just marked by a painted white line or by green road paint along the bicycle lane, produces a marked difference in the positioning from the road edge. A higher level facility, green road paint, increases the bicycles displacement from the road edge [25]. The presence of a paved shoulder resulted in a similar position as a bicycle lane. Total roadway width also impacts on the distance the cyclist chooses to travel from the road edge. Research has shown that as the total road width increases, so too does the distance between the bicycle and the kerb [26]. A cyclists positioning is also influenced by the speed limit, the number of traffic lanes and the presence of a vehicle. However, further information about the impact of these factors was not presented [26].

Early research found that the mean separation distance between bicycle and vehicle, an inferred measure of safety, depends primarily on the vehicles available travel space. In this instance travel space is defined as the distance between the centre line and the bicycle [12]. Subsequent research supports this, finding that the distance between cyclist and vehicle is determined by total roadway width and facility type [26]. A wide kerb lane, rather than a traffic lane with a marked bicycle lane found that there was greater separation between bicycle and passing vehicles [26; 27; 21; 25]. However, further research has shown that when additional vehicles are present during a bicycle passing manoeuvre the lateral displacement between the initial vehicle and bicycle is decreased [26]. While the presence of a bicycle lane sees a reduction in the lateral displacement between bicycles and vehicles, it does result in vehicles behaving in a more predictable manner. On roads where a bicycle lane is present, vehicles were observed making fewer wide swerves or close passes (Kroll & Ramey, 1997). Research has shown that the positioning of vehicles, in relation to bicycles, is also influenced by other factors including urbanization and the existence of gutter pan. Results have shown that the separation between bicycle and vehicle is reduced in urban areas and where a gutter-pan is present [27].

There is little identified research that investigates the hypothesis that on-road bicycle lanes improve the safety of cyclists. One paper was identified that directly investigated the effect of the presence of an on-road bicycle facility on crash frequency. Contrary to the common assumption, research from New Zealand found there that there was a reduction in crash frequencies over time in locations where bicycle facilities were not present [21]. It is difficult to draw conclusions based on the results of one investigation based on a single intervention site with low exposure to bicycles. Further research would be required to validate the results. As yet there are no similar studies on which to base comparisons.

Modelling research has been conducted to assess the impact of various design points for urban roads on bicycle crash severity. This research has found that two design factors influence bicycle safety. The two identified factors are: total roadway width and the road classification (freeway, arterial or local). Several other factors also impact on crash severity and these include traffic volume, truck density, population and commercial density [28]. Crashes resulting in serious injury were more likely to occur on wider roads, and with lower traffic volumes. Higher levels of injury severity with lower traffic volumes may be explained through the possible increase motor vehicle speeds, which may increase as traffic volume decreases. No relationship between roadway width and roadway type was examined, although this may explain the results that suggest wider roads resulted in crashes with greater injury severity. An increase in truck traffic density has also been associated with a reduction in cyclist safety. While this is not investigated further, the reduction in safety may be a result of the increased vehicle width requirements of heavy vehicles [28]. Additional research investigating factors affecting bicycle crash severity focuses mainly on rural roadways. This research has shown that roadway design has little impact on crash severity, with traffic volume, visibility and the road gradient found to be the only significant factors [29].

Conclusions

It is difficult to draw definitive conclusions regarding the impact of reduced lane widths on urban roads for the safety of all road users. Substantially more research is required in the area of safety interventions, such as marked bicycle lanes, to assess their effectiveness in improving the safety of cyclists on urban roads. While

specific research regarding road design and cyclist safety is currently lacking, research in related areas of road design has demonstrated some results that could improve road user safety.

A reduction in traffic lane width could provide additional space on the roadway reserve for the retrofitting of marked bicycles, or wider kerbside lanes. Narrower traffic lane width could reduce the financial and spatial burden of new roadways. Research has demonstrated that a reduction in road width results in changes of measured driver behaviour that could improve the safety of cyclists. Research from simulator and experimental research suggests that a narrowing of lane widths results in drivers self-selecting a reduced travel speed in free flow traffic environments. This reduction in travel speed provides a number of benefits, increasing the safety for cyclists, pedestrians and vehicle occupants. There is an inverse relationship between travel speed and vehicle handling ability. A reduction in self-selected travel speed in free flow conditions decreases speed variability, which in turn reduces the risk of vehicle crashes. In the event of a collision, reduced vehicle speeds significantly improve the outcome for the cyclists and pedestrians [30; 27].

Early research has demonstrated that a reduction in lane width does not correspond to an increase in perceived risk by the driver. The reduction in travel speed associated with narrow lane widths may explain the absence of significant difference in the perceived risk. Further research would be required to clarify this finding. However, decreased lane width does increase the task difficulty of driving. The safety implications of this increased demand through lane narrowing have not been investigated. Any increase in task difficulty may be compensated by the decreased travel speed, having no effect on the safety of vehicle occupants.

If narrow lane widths were to be implemented, it would be important to consider the typical vehicle types utilising the infrastructure. Reducing lane widths on road with higher proportions of heavy vehicles may be impractical, and reduce safety if lane widths are reduced to an extent that heavy vehicles were unable to avoid lane incursions. On urban roads, where speeds are limited to 70kph, with a low density of extreme heavy vehicles (such as A-Triples and Rigid +3s), this may not be an important consideration. One alternative that may result in the same effect on general traffic of narrow lanes, and maintain the safety of heavy vehicle traffic, would be to create heavy vehicle lanes that were wide enough to accommodate heavy transport vehicles.

Very little research exists in the area of geometric road design and cycling safety, and it is acknowledged that further research is required to draw definitive conclusions regarding the safety of these interventions. One road treatment frequently employed to improve road safety is marked bicycle lanes. Implementation of marked on-road bicycle lanes may not have the proposed effect on cycling safety. While it has been shown that bicycle lanes improve the interaction between bicycles and vehicles, primarily making travel paths more consistent, several factors indicate they do not improve the level of safety. In locations where a cycle lane exists, the lateral clearance between bicycle and vehicle is reduced. This may suggest that current recommendations for bicycle lanes are insufficient, or a wider lane marker is required to separate bicycles from vehicles. Early research also suggests that the construction of on-road cycle lanes does not reduce crash frequency. However, further research is required in this area. It would be important to consider the relevance of share bicycle/parking lanes in reference to improving cyclists' safety. Data from South East Queensland has shown that 5.3% of all reported bicycle crashes involve a collision with a parked vehicle [31]. Information on the proportion of these crashes occurring in marked shared lanes is not yet available. Further research is required to determine the efficacy of marked bicycle facilities, whether marked exclusive bicycle lanes or shared bicycle/parking lanes.

Additional research suggests that the safety improvements, such as reduced vehicle speed, made by narrowing lane widths may be lost if the total available roadway width is not reduced. Further research regarding this topic relating to this phenomenon is required with respect cycling safety, particularly if the effect is evident when bicycle lanes are introduced.

To conclude, the present research base suggests that a reduction of lane widths could result in increased safety for all road users. Further research is required in the area to reach a definitive conclusion regarding the impact of narrow road lanes on cyclist safety in urban areas.

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